each finite step in the program, you are immediately informed of the correctness of your understanding. This immediate feedback is one of the important features of programmed instruction. It provides correction when necessary; but more important, it verifies when you have correctly grasped what is being taught.

HOW TO USE THIS PROGRAMMED TEXT

This program is divided into twenty-four sets. Each set contains three components: (1) an introduction to the set, (2) the programmed instruction portion of the set, and (3) a series of exercises.

(1) The Introduction

Before each set in the program a brief introduction statement describes the content of the programmed portion of the set and provides additional information not contained in the programmed portion. You should read the introduction to each set carefully since it gives you a frame of reference for the instruction that follows. The introduction also states the specific objectives to be achieved in the set. These objectives alert you to the important aspects of statistics to be presented in the set and provide a clear picture of what you can expect to learn from the set.

(2) The Program

Each set of the program contains a number of small units, called *frames*. Each frame presents some information and includes a blank space which you are to fill in. The correct response to each frame, which is given immediately below it, should be kept covered with a card or sheet of paper until after you have written your response to the frame.

You are given some cues as to the type of response required in each frame. For instance, the number and size of the blanks indicate the number and size of words required. In some frames there is a series of alternatives from which you are to choose. For example, "Grass is _____ (green/red/blue)." Some frames require you to provide a symbol. This is indicated by the word (symbol) following the blank. For example, "When you wish to express dollars you use __ (symbol)."

(3) The Exercises

At the conclusion of each set there is a series of exercises. The exercises in this book are an integral part of the instructional process and all are to be completed. They provide a self-test by which you may determine whether you have grasped the material in the set. You will notice that the exercises exactly parallel the objectives as stated in the

a programmed introduction to STATISTICS

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PREFACE

This programmed introduction to statistics presents instruction in a logical sequence which allows the student to participate actively in the instruction process. It is written for students being introduced for the first time to statistical techniques and to the application of those techniques. It may be used for individual study or in undergraduate or graduate courses. It may be used as the only statistical text for a course or as an auxiliary text.

The focus is primarily upon the student who is unfamiliar either with the basic concepts of statistical techniques or with the mathematics needed to apply these techniques. Only a rudimentary knowledge of algebra is needed. This program is a beginning course, and stresses application; it does not attempt to develop theoretical or mathematical derivations of the various techniques.

Statistics is a difficult subject for many students. The major reasons for this may be that too much instruction is given at one time, that the material is not logically organized so that the student can follow its development, or that the student is not actively engaged in the instructional procedure.

Programmed instruction attempts to solve these problems by allowing the student to participate actively in every portion of the instructional process, by presenting instruction organized so that each step leads in logical sequence to the next, and by allowing the student to proceed at his own pace through the program—quickly through those areas that present no difficulty and more slowly where he feels it necessary. An additional advantage in programmed instruction is that after each finite step in the program, the student is informed immediately of the accuracy of his understanding. This immediate feedback is one of the important features of programmed instruction. It provides correction when necessary; more important, it verifies when the material has been correctly grasped, thus reinforcing learning.

This material has been field tested thoroughly. It has undergone three revisions and has been used by hundreds of students in several types of courses involving the study of statistics. The rate of student error in frame responses is well under five percent, and before-and-after testing has shown gratifying increases in student mastery of statistics.

This text is logically organized into twenty-four sets. Each set is self-contained and can usually be completed at one sitting. A brief set introduction describes the contents of each set and presents specific objectives for that set. These stated objectives alert the student to the important aspects of statistics to be covered in that set.

Each set contains a series of frames written and sequenced so that the required responses can be determined easily. The correct response is given immediately below each frame. It is this process of presenting the material in sequenced frames, each requiring a positive response, then immediately providing a check for the accuracy of the response, that constitutes the concept of "programmed" instruction.

At the end of each set is a series of exercises. They are an integral part of the instruction, providing a self-test and giving the student opportunity to apply what he has learned. The exercises parallel exactly the objectives set out in the introduction to each set.

Another unique feature of this book is the presentation of formulas, tables, and a glossary of symbols at the rear of the book. These can be removed for convenient reference while the student is working in this text and kept for permanent reference later.

All data presented in this text are fictitious and were developed specifically to illustrate this program. In order to reduce computational drudgery, the amount of data presented is kept to the minimum necessary to illustrate the statistical techniques.

Conventional symbolic notation has been used throughout the text so that it may be used with standard statistical texts without confusion.

I wish to express my sincere appreciation to Professor Samuel Levine for his advice and encouragement during the writing of this text. Grateful acknowledgement is also given to Professors Derek Nunney of Wayne State University, Gerald C. Helmstadter of Arizona State University, Frederick J. McDonald of Stanford University, Omer J. Rupiper of the University of Oklahoma, Garlie A. Forehand of Carnegie Institute of Technology, and Harold Jonsson and Samuel Levine of San Francisco State College for field testing preliminary editions of this text in their classes.

My particular gratitude goes to Bert Baecher for generously making available the appropriate psychological surroundings during the writing of this book.

I am indebted to the literary executor of the late Sir Ronald A. Fisher, F.R.S., Cambridge, to Dr. Frank Yates, F.R.S., Rothamsted, and to Messrs Oliver & Boyd Limited, Edinburgh, for permission to reprint Tables Nos. III and IV from their book *Statistical Tables for Biological, Agricultural and Medical Research.*

I am also indebted to the literary executor of the late Sir Ronald A. Fisher, F.R.S., Cambridge and to Oliver & Boyd Limited, Edinburgh, for their permission to reprint Table No. V.A. from their book *Statistical Methods for Research Workers.*

While only the author can assume responsibility for the content of a book, and for any errors which may have escaped, I would nevertheless like to express my thanks to Andrew Watson, whose editorial ability contributed measurably to the readability of this book, and to Terry Hendrix, who organized and directed the field testing.

CONTENTS

INTRODUCTION

In this program you will learn a number of statistical techniques, their statistical formulas, and when and how to use them. In order to use this program, you need only a rudimentary knowledge of algebraic procedures (that is, the use of symbols and the solving of simple algebraic equations). Even if you are weak in these areas, you should be able to use this program, since much help in computation is given, especially in the early sets.

WHY THIS TEXT IS IN PROGRAMMED FORM

This text presents a new method for learning statistics in which you: (1) actively participate in every portion of the instructional process; (2) are presented with step-by-step instruction organized so that each step leads logically to the next; and (3) are allowed to proceed at your own pace through the program, moving quickly through those areas that present no difficulty and more slowly where you feel it necessary. After